A conceptual framework for the impact of obesity on risk of cesarean delivery

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Cesarean deliveries accounted for 32.2% of nearly 4 million births in the United States in 2014. Obesity affects a third of reproductive-age women and is associated with worse cesarean delivery outcomes. Studies have shown that increasing maternal body mass index correlates linearly with cesarean delivery rates, but little is known about the potential mediating and moderating mechanisms. Thus, a conceptual framework for understanding how obesity correlates with risk of cesarean delivery is crucial to determining safe ways to reduce the cesarean delivery rate among obese gravidas. Based on an extensive review and synthesis of the literature, we present a conceptual framework that posits how obesity may operate through several pathways to lead to a cesarean delivery. Our framework explores the complexity of obesity as an exposure that operates through potential mediating pathways, a moderator of cesarean delivery risk, and a covariate with other cesarean delivery risk factors. Among nulliparas, obesity appears to operate through 3 main proximal mediating mechanisms to increase risk of cesarean delivery including: (1) preexisting comorbidities and obstetric complications; (2) a slower progression of first-stage labor, potentially increasing the risk of cesarean delivery secondary to failure to progress; and (3) a prolongation of pregnancy, which is associated with risk of maternal postdates. For multiparas, a fourth proximal mediator of prior uterine scar may also increase cesarean delivery risk. Distal mediating mechanisms, which operate through one of the proximal mechanisms, may include an induction of labor or planned prelabor cesarean delivery. Obesity may also moderate the likelihood of cesarean delivery by interacting with clinician-level or hospital-level factors. Future research should assess the validity of this framework and seek to understand the relative contributions of each potential pathway between obesity and cesarean delivery. This will allow for evidence-based recommendations to reduce preventable cesareans among obese women by targeting modifiable mediators and moderators of the relationship between obesity and increased risk of cesarean delivery.

Key words: cesarean delivery, obesity, pregnancy, theory

Introduction

Increasing maternal body mass index (BMI) correlates linearly with cesarean delivery (CD) rates.[1–4] Of nearly 4 million births in the United States in 2014, 32.3% were CD[5] and nearly 50% were to women who were either overweight (25.6%) or obese (24.8%) before becoming pregnant.[6] Obese women who have a CD experience more adverse peripartum outcomes including thromboembolic risks,[7] infections,[8] blood transfusions,[9] and maternal death when compared to normal-weight women with CDs or obese women with vaginal deliveries.

Clinical obstetric consensus is that CD can be lifesaving for the fetus, the mother, or both.[10] High-risk pregnancies, including those with comorbid conditions that increase risk of failing vaginal delivery or poor vaginal delivery outcomes, benefit from CD. However, the rapid rise in CD rates without a concomitant improvement in maternal and neonatal outcomes, coupled with an accrual of morbidity over multiple CDs,[11] suggests that CD rates are higher than necessary. One of the maternal, infant, and child health objectives of Healthy People 2020 is to reduce CD among low-risk women.[12] Since obese gravidas comprise a growing proportion of the obstetric population and experience CD at higher rates, safely reducing the national CD rate will require addressing the CD rate in this subgroup. Addressing preventable CD in obese women—those who would have had better maternal and fetal outcomes with a vaginal delivery—will require an understanding of the indications and preferences that lead to a CD. However, little is known about the mechanisms through which obesity increases risk of CD, making it difficult to suggest evidence-based recommendations to reduce preventable CDs among obese gravidas.

We propose a conceptual framework that posits how obesity may operate through several epidemiological pathways to lead to or modify risk of a CD. Drawing from an extensive literature, we highlight key distinctions that should be made when assessing the association, present potential mediating pathways, and explore the complexity of obesity as both an exposure and a moderating factor. In this review, we define maternal BMI by World Health Organization categories: normal weight, 18.5–24.9 kg/m^2; overweight, 25.0–29.9 kg/m^2; obese, class I, 30.0–34.9 kg/m^2; obese, class II, 35.0–39.9 kg/m^2; and obese, class III, ≥40 kg/m^2.[13]

Obesity and risk of CD

Obesity is not an indication for a CD[10] and does not meet the formal

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definition of a high-risk condition for CD.[14] Nevertheless, the association between maternal BMI and elevated risk of CD has been demonstrated in various populations and practice settings.[1] A large study from France reported a significant linear trend between 6 BMI groups and risk of CD that held when adjusting for presence of diabetes, term pregnancy, short stature, nulliparity, and maternal age; and when stratifying by subgroups such as women with gestational diabetes or very short stature (<1.50 m).[2] Similar results were reported in a cohort of nulliparous women who experienced spontaneous labor.[15] A study from Ireland found a progressive reduction in the likelihood of vaginal delivery among nulliparas in the normal-weight group to those in the class III obesity group (83.1−55.3%), with a corresponding increase in likelihood of both nonlaboring/elective/prelabor (3.6% vs 14.1%) and laboring/emergent/intrapartum (13.3% vs 30.6%) CD.[3] Sarkar et al[16] concurred with these findings, but found that when stratifying the CD rates by nonlaboring and laboring routes, the trend only remained significant in the latter group, suggesting that obese women do not have elective CDs at a higher rate. A recent US-based study that included only laboring CDs found an increasing rate with rising BMI for nulliparas, multiparas without a prior CD, and multiparas with a prior CD: the risk of CD increased by 5%, 5%, and 2% for each 1-kg/m^2 increase in BMI in the 3 groups, respectively.[4] However, these studies varied in their ability to assess the indications for the CDs, such as whether they were elective or a result of medical indicators, including failure to progress or nonreassuring fetal heart tracing.

Proximal mediators of increased CD risk

For nulliparas, obesity appears to operate through 3 main proximal mediating mechanisms (Figure). These include: (1) an increased incidence of preexisting medical comorbidities and obstetric complications, (2) a prolongation of pregnancy/delayed onset of spontaneous labor, and (3) slower progression during labor/overall longer duration of labor. For multiparas, history of a CD serves as a fourth potential mediator of increased risk of CD in the current pregnancy.

Preexisting comorbidities and obstetric complications

Obese individuals, and obese women of reproductive age in particular, have a higher incidence and severity of preexisting medical comorbidities including diabetes mellitus[17] and hypertension.[18] For women without these conditions, pregnancy-associated insulin resistance may induce preexisting but subclinical cardiometabolic dysfunction to emerge.[19] Thus obese women are more likely to develop obstetric complications including gestational diabetes, preeclampsia, eclampsia, and higher estimated fetal weight,[20−22] all of which may serve as indications for a CD.[23]

Prolongation of pregnancy

Obesity has been associated with prolongation of pregnancy, which has been defined as a longer average gestation,[24] higher likelihood of reaching a given gestational age cut-off such as 41$^{0/7}$ weeks,[25] or higher likelihood of becoming a postterm pregnancy as defined by a given practice association or institution,[26,27] when compared to a normal-weight group. Delayed onset of spontaneous labor has been linearly associated with maternal BMI.[24−26] This trend held even after restricting to women who experience spontaneous labor, thus reducing the impact of interventional induction of labor (IOL) or CD,[24] or after adjusting for maternal age, race, parity, hypertension, diabetes, and smoking status.[26] For example, Denison et al[24] found that overweight, obese class I, and obese class ≥II had a 0.71, 0.57, and 0.43 odds of spontaneous labor at term, respectively, when compared to the referent group of normal-weight women.

Due to excess perinatal morbidity and mortality[28,29] with a linearly increasing risk of stillbirth in obese women[30] as each week of gestation >39 weeks passes, prolongation of pregnancy has been correlated with lower likelihood of spontaneous delivery at term,[24] higher likelihood of an IOL,[26,27,31] and lower likelihood of induction success.[26,32] Various physiological theories have been proposed to explain delayed onset of spontaneous labor in obese women. These include: (a) uterine quiescence or a suppression of myometrial activity, possibly via the inhibitory effects of leptin[33] or hypercholesterolemia and reduced calcium flux[34] as shown through in vitro studies; (b) endocrine theory positing that maternal obesity is associated with lower corticotrophin-releasing hormone and cortisol levels, which may impact fetal lung maturation[35] and length of the pregnancy;[36,37] (c) erroneous gestational dating since obese women are more likely to be oligoovulatory;[38,39] and (d) potentially elevated estrogen levels due to more adipose tissue, leading to delayed parturition.[25,38] Apparent prolonged pregnancy may also be an artifact of inadequate adjustment for competing risks: an obese woman is more likely to be induced at 37 weeks for preeclampsia, thus eliminating the opportunity to go into spontaneous labor at term. Additionally, it should be noted that obesity has been associated with risk of medically indicated preterm birth, although the association with spontaneous preterm birth is less clear.[21,22,40−42]

Slower progression of labor

In the first stage of labor, obese women progress more slowly, taking longer to reach both active labor and the second stage of labor. Kominiarek et al[43] found that they have a more gently sloping labor curve, as indicated by median cervical dilation traverse time from 4−10 cm, with increasing BMI in both nulliparas (5.4 hours for normal weight vs 7.7 hours for class III obesity) and multiparas (4.6 hours for normal weight vs 5.4 hours for class III obesity).[43] This trend held for induced and spontaneous labor. Nuthalapaty et al[44] found that rate of cervical dilation decreased by 0.04 cm/h per 10-kg increase in weight ($P = .05$) among nulliparous women, even though women of higher BMI received a higher mean maximum oxytocin rate and achieved higher average maximum uterine contractility.[44] Among